Diabetes in Mexico. CARMELA study

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Abstract

Background: Diabetes has demonstrated an epidemic behavior in Mexico, which is among the top countries with the highest number of patients with diabetes. The objective of this study was to estimate the prevalence of type 2 diabetes in Mexico City and its relation with some cardiovascular risk factors.

Methods: A cross-sectional study was conducted. A total of 1,772 adults of both genders, aged 25 to 64 years, were randomly selected. Type 2 diabetes and impaired fasting glucose prevalence were estimated as well as its relation with some cardiovascular risk factors such as hypertension, dyslipidemia, obesity, abdominal obesity and the common carotid artery intima-media thickness.

Results: The prevalence of type 2 diabetes was 9.7% in women and 8.0% in men. An age effect was evident. The proportion of patients who were unaware of having diabetes was 26%. The main risk factors related to diabetes were age, abdominal obesity, hypertension, low high-density cholesterol lipoproteins (HDL-c) and hypertriglyceridemia. Metabolic control was low.

Conclusions: Prevalence of type 2 diabetes in Mexico is high and is a major health problem. Its close relation with cardiovascular risk factors demand health policies aimed to diminish risk factors related to its occurrence.

Key words: type 2 diabetes, prevalence, cardiovascular risk factors.

Introduction

Diabetes mellitus (DM) has shown an epidemic behavior in Mexico since the second half of the last century.[1] Currently, Mexico is one of the countries with the highest occurrence of diabetes worldwide. In 1995 it occupied the 9th place with the highest number of DM cases and it is expected that in 2030 it will occupy the 7th place with almost twelve million patients with type 2 DM.[2] DM is currently the leading cause of death in Mexico and the trend shows a progressive increase in recent years.[1,3] In 2008 there were >75,500 deaths in Mexico due to DM representing a mortality rate of 73.6 for females and 63.4 in males per 100,000 inhabitants.[4] In the population covered by the Instituto Mexicano del Seguro Social (IMSS), the largest social security institution in the country with an affiliated coverage of nearly half the Mexican population, DM is the leading cause of mortality, of years lost due to premature death, years lived with disability and years of healthy life lost.[5] In 2000, DM contributed with 13.30% of the years of healthy life lost in the IMSS.[5]

DM is a clear example of the epidemiological transition taking place in Mexico as well as the transition from health care.[6] It is estimated that the cost of DM care in Mexico is more than 300 million dollars (USD) per year and the behavior shows an ascending pattern in the coming years.[7] Mexico City accounts for 12% of the deaths from DM in males in the country and its rate of age-adjusted mortality is the second highest nationally (123.0/100,000 males in 2008). In females, 11% of deaths from DM occur in Mexico City representing an age-adjusted rate of 94.0/100,000 females in 2008. [4] In the National Health Survey conducted in 2000, the prevalence of DM in Mexico city was 8.5%, ranking seventh highest in occurrence among all Mexican states.[8]

DM in Mexico has been strongly associated with genetic background as well as arterial hypertension, obesity, diets

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rich in simple sugars and lack of exercise.[9-12] Recently, the CARMELA (Cardiovascular Risk Factor Multiple Evaluation in Latin America) study was carried out in seven Latin American cities, including Mexico City, to assess the frequency and distribution of major cardiovascular risk factors, including intima-media thickness (IMT) of the common carotid artery.[13] The aim of this report is to present the results of this survey in Mexico City regarding the prevalence of DM and impaired fasting glucose as well as its relationship with principal cardiovascular risk factors.

Materials and Methods

This study is part of the CARMELA study of the prevalence of cardiovascular risk factors in seven Latin American cities. We conducted a cross-sectional study of prevalence. We studied individuals with an age range of 25 to 64 years divided into four decennial groups. For sample selection, we sought to include 400 subjects in each decennial age group (200 males and 200 females) using a stratified multistage sampling. For this goal, we considered the political delegations of Mexico City such as strata and in each delegation we obtained a basic geostatistic area (BGA) provided by the National Institute of Statistics and Geography. We randomly selected initial clusters or first-stage units (BGAs).

Within each BGA there are randomly selected households in our second stage of selection, through systematic sampling with sampling fractions determined according to the average number of eligible subjects (i.e., the intended age group) per home. We used the population pyramid according to the Census of Population and Housing (2000).

In the third selection stage, individuals included in the study were chosen by a probabilistic procedure. The homes selected in the second stage were classified into four categories. In the first category we interviewed all residents between the ages of 25 to 64 years in the selected dwelling. The second category included those who were 35 to 64 years old. In the third category only subjects between 45 and 64 years of age were interviewed and in the fourth category only those 55 to 64 years old participated in the study. Thus, the fraction of the sample in each category had an equal probable sample for each age group and gender. With this strategy, we minimized the number of homes visited because the size of the age groups decreases with age. Sample size was adjusted for a nonresponse rate obtained in a pilot exercise and was estimated at 35%. Neighborhood blocks were excluded that had no homes and those in marginalized areas where the safety of the interviewers was compromised.

Interviews and Clinical Measures

Selected subjects were interviewed in their homes by trained personnel who were certified by CARMELA study investigators. They were given a semistructured questionnaire on sociodemographic variables as well as some cardiovascular risk factors such as history of arterial hypertension, diabetes mellitus, hypercholesterolemia, and smoking. All subjects were scheduled to arrive at the research unit for blood sampling and anthropometric and clinical measurements including ultrasound for measurement of carotid IMT.

Height was taken with the individual barefoot standing on a vertical stadiometer, approximating the reading to the nearest centimeter. Weight and waist circumference (WC) were measured wearing light clothing, approximating the weight to the closest half-kilogram and waist measurement to the nearest half-centimeter. WC was measured at the midpoint between the lowest rib and the iliac crest. Arterial blood pressure was measured twice with 5-min difference between them, using a mercury sphygmomanometer. If the difference was >5 mmHg, measurements were then repeated until two consistent measurements were obtained.

After a 12-h fast, blood samples were taken for the determination of glucose, total cholesterol and its fractions, low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c), and triglycerides.

Clinical Definitions

DM was considered when concentrations of glucose in the venous blood were 126 mg/dl or when the individual reported a previous diagnosis of diabetes. Impaired fasting glucose was considered when the glucose values were between 110 and 125 mg/dl. In subjects with previous diagnosis of diabetes, glycemic control was considered when the values were <110 mg/dl.

To measure obesity, a BMI reading was calculated by dividing weight (kg) by height (m) squared. Obesity was defined as having a BMI ≥30 kg/m^2. Abdominal obesity was considered when WC was >102 cm in males or >88 cm in females. Arterial hypertension was diagnosed when the subject presented values ≥140/90 mmHg or when the subject referred to using antihypertensive medications. IMT was measured according to the Mannheim consensus.[14] For analysis, we considered tertiles of thickness values obtained in the study population.

Statistical Analysis

Statistical analysis considered the non-equiprobability character of the sample and structure of the design. The prevalence was obtained as a measure of the occurrence and the odds ratio (OR) as a measure of comparison, with 95% confidence intervals (95% CI), adjusting for age and gender. Logistic regression model was done to evaluate the strength of the association of diabetes with multiple risk factors, such as age, gender, lipid level concentration, arterial hypertension, obesity and abdominal obesity, as well as IMT of the common carotid artery.

Results

We studied 1,722 participants: 833 males (48.4%) and 889 females (51.6%). Distribution according to age group and gender is shown in Table 1. The prevalence of diabetes, adjusted for age and gender, was 8.9% higher in females (9.7%) than in males (8.0%) (Table 2). The prevalence showed a clear age effect, from 3% in the youngest age group (25 to 34 years old) to 22% for those subjects 55 to 64 years of age. In this latter age group, 1/4 males and 1/5 females had diabetes. In fact, glucose concentrations increased with age (Figure 1) and, consequently, the prevalence impaired fasting glucose also showed a clear age effect (Table 3).

The vast majority of the participants reported having a previous blood glucose measurement and the proportion of individuals with a previous blood glucose measurement increased with age and increased from 64% in the youngest age group (25 to 34 years old) to 90% in those subjects 55 to 64 years of age (Figure 2). This perhaps is the reason why only 26% of the study subjects with diabetes were unaware of having diabetes (Figure 3). It is noteworthy that this ratio was 43% in the 35- to 44-year-old age group.

In Table 4 we identify that DM is associated with age, abdominal obesity, arterial hypertension, low HDL-c and hypertriglyceridemia. The second column shows the prevalence of diabetes according to the presence of risk factors analyzed. The far right column presents the estimates of the ORs with 95% confidence intervals. It is observed that subjects with hypertension have a 48% excess risk of diabetes (OR = 1.48, 95% CI = 1.01 to 1.26), whereas those with low cholesterol had an excess risk of 84% (OR = 1.84, 95% CI = 1.22 to 2.76) and an excess risk of 95% in those subjects with hypertriglyceridemia >200 mg/dl (OR = 1.95, 95% CI = 1.27 to 2.99).

Glycemic control in the population with previously diagnosed diabetes is low and is inversely related with age. Therefore, 58% of the patients with previously diagnosed DM (25- to 34-year-old group) reported control of their disease, but only 34% of those in the 55- to 64-year-old group reported the same (Figure 3).

Discussion

The prevalence of DM in Mexico City is elevated and undoubtedly represents a major public health problem. The prevalence is conditioned by the incidence and mortality. To the extent that it decreases the lethality of the disease, the prevalence increases but also directly increases as the occurrence increases. In Mexico, a gradual and progressive decrease has been documented of the mortality due to DM.[15] Incidence is elevated, but certainly less than seen in the Hispanic population living in the U.S.[16] The prevalence of DM significantly increased in Mexico City during the second half of the last century but has remained stable

Table 1. Distribution of the study population according to age and gender

Age (years)	Male *n*	Male %	Female *n*	Female %	Total	
25-34	207	49.29	213	50.71	420	24.39
35-44	212	49.07	220	50.93	432	25.09
45-54	215	46.14	251	53.86	466	27.06
55-64	199	49.26	205	50.74	404	23.46
Total	833	48.37	889	51.63	1 722	100.00

Table 2. Prevalence of T2DM (95% CI) by age and gender

	Male		Female		Total	
Age (years)	P (%)	95% CI	P (%)	95% CI	P (%)	95% CI
25-34	2.4	0.3-4.6	4.2	1.8-6.7	3.4	1.8-4.9
35-44	4.2	1.8-6.7	7.7	4.2-11.3	6.1	3.9-8.3
45-54	14.4	8.4-20.4	16.3	11.9-20.8	15.5	12.2-18.8
55-64	26.1	20.6-31.6	19.0	13.6-24.4	22.1	18.5-25.7
Total	8.0	6.3-9.7	9.7	7.8-11.6	8.9	7.7-10.2

T2DM, type 2 diabetes mellitus; P, prevalence (%); 95% CI, 95% confidence intervals.

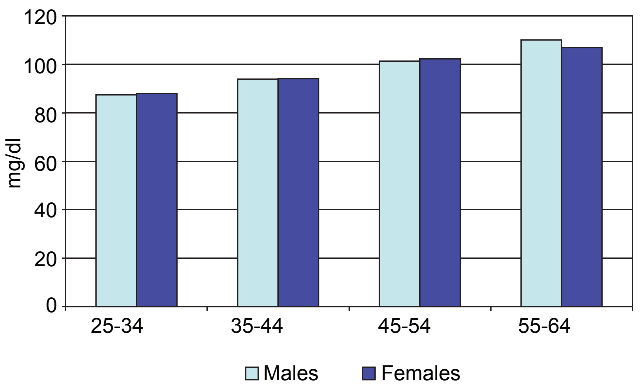

Figure 1. Average fasting glucose values according to age and gender in an adult population of Mexico City. CARMELA study.

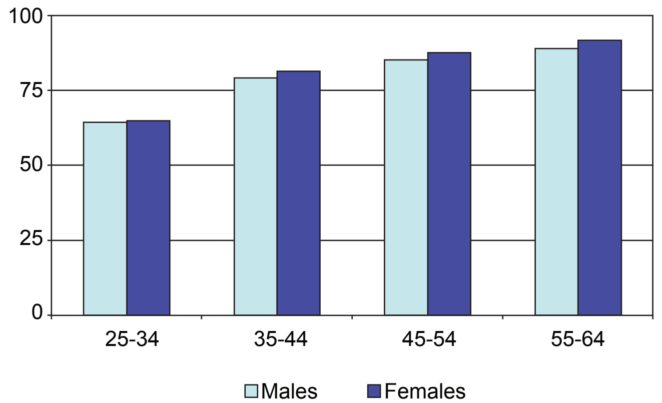

Figure 2. Proportion of adults interviewed in Mexico City in the CARMELA study with previous blood glucose measurement according to age and gender.

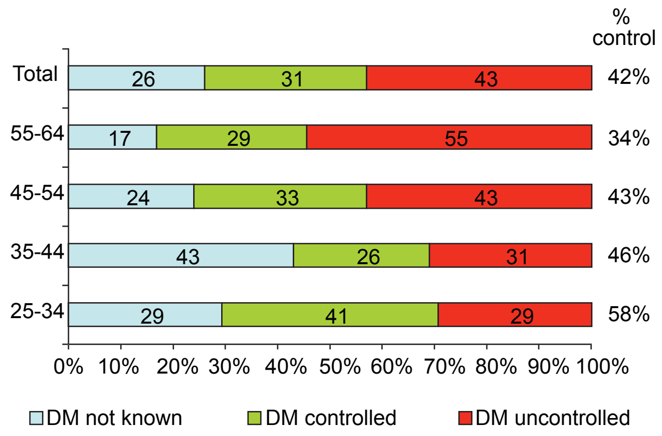

Figure 3. Proportion of patients with type 2 diabetes mellitus without previous diagnosis (finding of the survey) and proportion of control of diabetes among those already known to have the disease.

during the last two decades. Early reports on the occurrence of diabetes in Mexico City in the 1960s reported a prevalence of between 2 and 3%.[17,18] Three decades later, the prevalence was estimated to be three to four times higher in various studies, reflecting an increase in the exposure to risk factors and, indirectly, an increased occurrence of the disease.[9-12]

Age is a clear risk factor for developing diabetes. Although it can be inferred that exposure to risk factors for DM (factors related to lifestyle such as diet and physical activity) increase (and accumulate) with age, the fact is that insulin secretion decreases at a rate ~0.7% per year.[19] This may explain the observed increase in the average glucose

Table 3. Prevalence of impaired fasting glucose and of diabetes mellitus according to previous diagnosis or results of the study and level of control in subjects already diagnosed*

Age group (years)	Normal fasting glucose	Alteration of fasting glucose	Diabetes diagnosed in the study	Known diabetic subject	
				Controlled	Not controlled
Male					
25-34	96.1 (93.8-98.5)	1.4 (0.0-2.9)	0.5 (0.0-1.5)	1.4 (0.0-3.1)	0.5 (0.0-1.5)
35-44	92.9 (89.6-96.3)	2.8 (0.6-5.0)	2.4 (0.3-4.5)	0.9 (0.0-2.3)	0.9 (0.0-2.2)
45-54	77.7 (72.0-83.4)	7.9 (4.6-11.3)	2.3 (0.4-4.3)	6.0 (2.5-9.6)	6.0 (2.7-9.4)
55-64	67.8 (61.7-74.0)	6.0 (3.1-9.0)	6.0 (2.0-10.0)	7.5 (4.1-11.0)	12.6 (7.8-17.3)
Female					
25-34	95.3 (92.5-98.1)	0.5 (0.0-1.4)	1.4 (0.0-2.9)	1.4 (0.0-2.9)	1.4 (0.0-3.0)
35-44	89.1 (85.2-93.0)	3.2 (0.9-5.5)	2.7 (0.3-5.2)	2.3 (0.5-4.1)	2.7 (0.3-5.2)
45-54	80.5 (75.0-86.0)	3.2 (1.2-5.2)	4.8 (2.4-7.2)	4.4 (2.1-6.7)	7.2 (4.0-10.4)
55-64	74.1 (67.2-81.1)	6.8 (3.0-10.7)	2.0 (0.0-3.9)	5.4 (2.3-8.5)	11.7 (7.0-16.4)
Both genders					
25-34	95.7 (93.7-97.7)	0.9 (0.0-2.0)	1.0 (0.1-1.8)	1.4 (0.3-2.5)	1.0 (0.0-1.9)
35-44	90.9 (88.3-93.5)	3.0 (1.1-4.9)	2.6 (0.9-4.2)	1.6 (0.3-3.0)	1.9 (0.4-3.4)
45-54	79.2 (75.8-82.6)	5.3 (3.6-7.0)	3.7 (2.3-5.1)	5.1 (3.2-7.0)	6.7 (4.7-8.6)
55-64	71.4 (67.1-75.7)	6.5 (3.9-9.1)	3.7 (4.2-8.4)	6.3 (4.2-8.4)	12.1 (8.8-15.4)
Total					
25 a 64	87.9 (86.2-89.7)	3.1 (2.1-4.1)	2.3 (1.6-3.0)	2.8 (2.1-3.6)	3.8 (3.0-4.5)

*Population of Mexico City in the CARMELA study (*CArdiovascular Risk factor Multiple Evaluation in LatinAmerica*).

values with age. This deterioration in cell function is even more accelerated in subjects with impaired glucose tolerance.[19] The elevated prevalence of impaired fasting glucose is no less troublesome because between 40 and 50% of these subjects will develop diabetes within the following 20 years.[20]

The proportion of subjects who are unaware of having DM is low in Mexico City and much less than 50% as has been estimated in other populations.[21] The large proportion of respondents who reported having had previous blood glucose measurement probably explains the significant knowledge they had regarding the symptoms of diabetes. In some manner, screening programs may be contributing positively to the identification of the disease. However, the poor glycemic control highlights the gap that exists between the knowledge of the disease and proper control of the disease. The proportion of subjects with uncontrolled diabetes merits the focus of the National Health Survey[22] and is beyond the control achieved by other populations.[23] Poor glycemic control is a true challenge because the presence of microvascular complications increases in direct relation to poor control.[24]

Table 4. Prevalence of diabetes mellitus according to risk factors and ORs of the independent participation of each of the risk factors of diabetes*

	Prevalence (95% CI)		ORs (95% CI)	
Age group (years)				
25-34	3.4	(1.8-4.9)	1.0	
35-44	6.1	(3.9-8.3)	1.69	(0.87-3.29)
45-54	15.5	(12.2-18.8)	5.45	(2.84-10.45)
55-64	22.1	(18.5-25.7)	6.83	(3.68-12.69)
Gender				
Male	8.0	(6.3-9.7)	1.0	
Female	9.7	(7.8-11.6)	1.14	(0.77-1.70)
IMT of common carotid artery (tertiles)				
I	6.6	(4.2-8.9)	1.0	
II	7.6	(5.2-10.1)	1.05	(0.55-2.02)
III	13.6	(10.7-16.5)	1.52	(0.84-2.75)
Abdominal obesity				
Absent	6.0	(4.6-7.4)	1.0	
Present	12.6	(10.3-14.9)	1.38	(0.95-1.99)
Obesity				
< 25	4.6	(3.1-6.1)	1.0	
25-29.99	8.9	(7.0-10.8)	1.02	(0.63-1.66)
≥ 30	12.8	(9.8-15.8)	1.32	(0.78-2.23)
Arterial hypertension				
Absent	7.3	(6.0- 8.5)	1.0	
Present	21.7	(16.7-26.6)	1.48	(1.01-2.16)
LDL-c (mg/dl)				
< 100	8.5	(6.4-10.6)	1.0	
100-129	7.9	(5.5-10.3)	0.76	(0.46-1.26)
130-159	7.7	(5.3-10.1)	0.66	(0.41-1.07)
≥ 160	10.3	(6.2-14.3)	0.73	(0.41-1.30)
Low HDL-c#				
No	6.3	(5.0- 7.6)	1.0	
Yes	13.1	(10.6-15.7)	1.84	(1.22-2.76)
TGs (mg/dl)				
< 150	5.2	(4.0-6.5)	1.0	
150-199	8.8	(5.8-11.7)	1.23	(0.83-1.82)
≥ 200	14.6	(12.5-16.6)	1.95	(1.27-2.99)

*Derived from logistic regression model with 95% confidence intervals in a Mexico City population in the CARMELA (*CArdiovascular Risk factor Multiple Evaluation in LatinAmerica*) study.
IMT, intima-media thickness; abdominal obesity, waist circumference 102 cm in males, >88 cm in females; BMI, body mass index (kg/m^2); obesity, BMI ≥30 kg/m^2; hypertension, ≥140/90 mmHg or use of antihypertensive medications; LDL-c, low-density lipoprotein cholesterol; HDL-c, high-density lipoprotein cholesterol; low ≤40 mg/dl in males or ≤50 mg/dl in females; TGs, triglycerides.

The relationship of hypertension with DM is well known and has been previously documented in Mexico.[11-12] It is true that blood pressure values predict the risk of developing diabetes in the future.[25] A similar situation happens with hypertriglyceridemia. It has been documented that hypertriglyceridemia can, for several years, precede the occurrence of DM.[26] The CARMELA study in Mexico City showed a twofold increased risk of developing diabetes in subjects with TGs ≥200 mg/dl. Whereas both entities may be different phenotypic expressions of the same pathophysiological process, it has been observed that increased levels of TGs in healthy individuals predicts the risk of developing diabetes in the future.[27] In fact, the observed association of DM with blood levels of TGs and low levels of HDL-c probably expresses the close relationship between these parameters as part of the metabolic syndrome (MetS).[28]

The closer association of abdominal obesity with diabetes, compared to the obesity measured by body mass index (BMI), has been observed in previous studies in Mexico[12] as well as in other populations.[29] It is likely that the elevated prevalence of obesity in the population of Mexico City masks a larger association [13] Although imprecise, association with the IMT of the carotid artery shows the association of DM with atherosclerosis, probably as a joint expression of inflammatory processes that affect both entities.[30] A similar association of subclinical carotid atherosclerosis with MetS (and each of its components) was recently observed in the CARMELA study[31] (the present study is a branch of this study).

DM is a common disease in Mexico City affecting young adults and significantly affecting those of productive age groups. One of every six to seven adults between 45 and 54 years old and one in five of the age group of 55 to 64 years old have DM. DM is strongly associated with other cardiovascular risk factors, which probably expresses a base of common origin of these entities that have recently been combined to define MetS. [27] Nationally, we have observed an elevated prevalence of diabetes as well as other cardiovascular risk factors in the population covered by the IMSS, the largest social security institution in the country, protecting the health of nearly half of the Mexican population.[32] Due to the growing increase in the occurrence of DM and the growing involvement in the productive age groups, it is necessary to establish healthcare strategies to curb the upward trend in the occurrence of the disease and thus alleviate the high burden of diabetes.

In conclusion, 1/12 males and 1/10 females between the ages of 25 and 64 years in Mexico City have DM. The prevalence increases with age so that in the 55- to 64-year-old age group one in four males and one in five females suffer from the disease. Three quarters of the subjects with diabetes are aware of their diagnosis, but of those subjects, only 42% have their disease under control. Diabetes is associated with other cardiovascular risk factors such as hypertension, obesity, increased IMT, low HDL-c values and elevated blood triglycerides. Public health policies should be implemented in order to halt the advance of this epidemic in Mexico City.

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